Quantitative Spectroscopy of X-Ray Laser Plasmas in Pulsed Power Devices

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At the start of the reporting period indicated above the original Z-pinch setup was in place and running. Diagnostics consisting of a framing camera, 1 m N.I. VUV spectrometer, 1/2 m visible spectrometer and a Rogowski coil had been set up and were functional.

To begin, with a framing camera a study of the visible signature of the plasma for a variety of different conditions (e.g., gas voltage in discharge, etc.) was conducted. This gave a working understanding of the gross behavior of the discharge. The emphasis was shifted to obtaining a temporal sequence of time resolved photographic spectra which would include the 5f-3d and 4f-3d transitions in CIV, the lines of primary interest for this experiment.

Preliminary steps, such as checking the calibration of the 1 m VUV spectrometer/MCP/photographic film with an Ar capillary discharge lamp, and the location of optimal discharge conditions/MCP pulse parameters/photographic film development procedures, were conducted. (mgm) ←

The spectra of interest were then taken, and microdensitometer traces of regions of those spectra were made. For a variety of reasons attempts to obtain an accurate calibration of MCP film exposure versus relative spectral

intensity were unsuccessful and only qualitative and order of magnitude conclusions could be drawn about various lineshapes and intensities. This gave only a rough figure for the spectrally derived electron density estimate.

At this juncture a quadrature interferometric diagnostic became operational. It was tested and then applied to obtain a side-on estimate of the electron density which agreed with the spectrally derived figure ($\sim 10^{17}\text{cm}^{-3}$). Geometrical uncertainties meant that this value was also subject to large uncertainty.

In the next phase of the experiment, design and construction of a second version of discharge vessel was undertaken. The motivation was to speed up the current and to obtain more classical Z-pinch behavior in the discharge. A new MCP with a linear response Reticon photodiode array detector was installed on the 1 m instrument. This detector was electronically read out to an IBM AT compatible PC where spectra could be analyzed and fitted. This new detector was tested, aligned and calibrated using the Ar capillary, discharge lamp.

Meanwhile, the performance of the previous MCP detector was degraded to a large degree due to its exposure to carbon and carbon-bearing compounds. This forestalled plans to run the second version of the discharge vessel in methane or with carbon electrodes. The discharge was operated in nitrogen, helium, hydrogen and argon, and diagnostics were conducted mainly for hydrogen and nitrogen. Framing camera studies revealed the expected Z-pinch behavior. The cross-shaped vessel (to facilitate diagnostic

access) however, is believed to be responsible for a lack of cylindrical symmetry, leading to inhomogeniety and possibly reduced stability on pinching. VUV spectra taken in N_2 revealed the NV resonance lines. A search for 5f-3d and 4f-3d lines of NV was without result, but also revealed the absence of all lines below 850 Å. The diffraction grating of the 1 m instrument was sent to be recoated.

The last two months of the period of this report were occupied by a third phase of the experiment. The design of a third version discharge vessel was completed and construction of the same is underway. Diagnostic upgrade and maintenance and the development of supporting software were also conducted. The new vessel should be complete and operational in the near future.

Our preliminary experimental results were presented as a poster at the November 1988 Division of Plasma Physics meeting.

Our theoretical work has been in two areas: scaling of Stark widths of Li-like lines which are laser candidates, and broadening and line splitting due to resonant interactions between radiation field and dipole moments associated with the lasing transitions. Rabi splitting is predicted at high power levels in ASE amplifiers.